Production Losses: How to Find and Reduce Them

By Herb Lichtenberg

Whistles are blowing, phones are ringing and people are scrambling all over the factory floor. There has just been a major equipment breakdown and it looks like it will take days to fix and get the plant running again. Just think of the lost production, the late orders and the unhappy customers. When something like this happens it gets a lot of attention from all levels in the organization.

It's happened to me on several occasions and these can be gut-wrenching times. For instance, I once managed a blooming and rolling mill complex. The blooming mill was powered by a 10,000 horse-power steam engine and everything had to go through that one mill. On this occasion one of the two piston rods fatigued and the piston blew through the cylinder head and was found 80 feet down the motor room. Luckily, no one was in the room at the time. Well, we lost two and a half days (61 hours actually), repairing the engine, its foundation and gearing. The incident got a lot of attention with an investigation, root cause analysis and implementing a procedure so it wouldn't happen again. Sound familiar?

These things happen in every plant, and, if dealt with properly (investigation, root cause analysis, implementation of countermeasures) will not happen again. But these single-event losses are not the real killers of production unless they occur frequently or are the result of a systemic problem such as an ineffective preventive maintenance program. The real killers of productivity are small events that are taken for granted or considered part of the process.

In the same complex I managed above, we experienced a delay that occurred on an average of twice per shift, three shifts per day, 365 days per year. Changing the "hot saw" was a routine, 7 minute delay and was considered a necessary part of the process because the steel had to be cut to length after being rolled. In our daily meetings it was hardly ever mentioned, even though we lost an average of 255 production hours each year for that single reason. Now, that's something everyone including the brass should have gotten excited about. But a seven minute delay in production just didn't generate much concern.

Remember the fuss over the broken piston shaft which caused 61 hours of downtime? Well, the saw change was just considered a part of the process and did not get much attention. However, the guy whose job it was to sharpen the saws saw the waste. By working with tool steel and carbide insert vendors he came up with a new saw design that lasted twice as long, adding 127 hours of production time per year to the mill. As this example illustrates, repetitive short duration delays that are considered part of the process, or are considered minor issues, can be a gold mine of productivity improvements. Look at the minor stops your plant incurs. There may be a wealth of productivity to gain with some very simple solutions.

The key to finding these opportunities is to first determine the OEE (Overall Equipment Effectiveness) of the process and develop a loss map for the three OEE factors (Uptime, Speed, Quality).

OEE is being used increasingly in industry because it takes the most common sources of manufacturing productivity losses and distills them into consistent metrics that are used to monitor and improve manufacturing operations. OEE is a hierarchy of metrics that can be used at the equipment, department, line and facility levels. It is a method that truly reduces complex production problems into simple, intuitive information that helps you to systematically improve your operation.

The two top view metrics, OEE (Overall Equipment Effectiveness) and TEEP (Total Effective Equipment Performance) are closely related measurements that report the overall utilization of the facility. These top view metrics directly indicate the gap between actual and ideal performance.

- OEE quantifies how well a manufacturing unit performs relative to its designed capacity, during the periods when it is <u>scheduled to run</u>. It breaks the performance of a manufacturing unit into three separate but measurable components: Uptime, Speed, and Quality. Each component points to an aspect of the process that can be targeted for improvement.

OEE = % Uptime x % Speed x % Quality

- TEEP measures OEE effectiveness against calendar hours, i.e.: 24 hours per day, 365 days per year. It reports the "bottom line" utilization of assets and is used when considering investment in additional production facilities.

TEEP = Loading x OEE

(It should be noted that for operations running 24/7, OEE will be greater than or equal to TEEP depending on the loading factor)

So in addition to helping you to focus your plant and equipment performance efforts, these measures can save your company from making inappropriate plant and equipment purchases.

There are four underlying metrics that provide understanding as to why and where the OEE and TEEP performance gaps exist. The measurements are described below:

- Loading: This portion of the TEEP metric represents the percentage of time that an operation is scheduled to operate compared to the total calendar time that is available. Things such as "turnarounds" and other planned downtime due to lack of orders are elements of loading.

Loading = Scheduled Time / Calendar Time

- Uptime: This portion of the OEE metric represents the percentage of scheduled time that the operation is running.

Uptime = Run Time / Scheduled Time

- Speed: This portion of the OEE Metric

represents the speed at which the work center runs as a percentage of its designed speed.

Speed = Actual Rate / Theoretical Rate

- Quality: This portion of the OEE Metric represents the good units produced as a percentage of the total units started (commonly referred to as First Pass Yield).

Quality = Good Units / Units Started

OEE helps to uncover inefficiencies in your production processes by showing you how well a production line is functioning overall in terms of Uptime, Speed, and Quality. The data produced by OEE helps you to direct the focus for your diagnostic and improvement efforts. The subsequent actions taken, based on the knowledge you've gained, will result in improved efficiency and reduced operating expense.

EXAMPLE

ABC Manufacturing Company's plant is scheduled to operate for 16 hours (960 minutes) per day, 5 days per week, 50 weeks per year. Last year the plant produced an average of 480 units per day of which 460 met the quality specifications. The plant also averaged one product changeover per day at 30 minutes per change and experienced an average of 100 minutes per day of unplanned downtime. The plant was designed to produce 40 units per hour. Calculate both OEE and TEEP for the plant.

Uptime

Scheduled Time = 960 minutes/day

Run Time = 960 minutes scheduled – (100 minutes unscheduled downtime + 30 minutes changeover) = 830 minutes/day

Uptime = 830 run minutes / 960 scheduled minutes = 86.5%

Speed

Actual Rate = 480 units / (830 run minutes / 60 minutes/hour) = 34.7 units/hour

Speed = 34.7 units/hour / 40 units/hour = 86.8%

Quality

Quality = 460 good units / 480 units started = 95.8%

OEE

OEE = 86.5% Uptime X 86.8% Speed X 95.8% Quality = 71.9%

Loading

Loading = (5 days x 16 hours x 50 weeks) / (7 days x 24 hours x 52 weeks) = 45.8%

TEEP

TEEP = 45.8% Loading X 71.9% OEE = 32.9%

As you can see from the example, calculating **OEE** and **TEEP** is not particularly complicated. However, care must be taken as to standards that are used as the basis. Most companies have fairly good systems for capturing and tracking uptime and quality data. However, at many brown field sites where modifications to the equipment and processes have been made over the years, determining the name plate/design rate can be somewhat contentious.

In order to develop the loss map we take the inverse of the Uptime, Speed and Quality percentages. For example if our Uptime, as in the example above, is 86.5%, the uptime loss is 13.5%. The next step in developing the Loss Map is to categorize the Uptime losses into Idle downtime, Unplanned downtime and Changeover downtime.

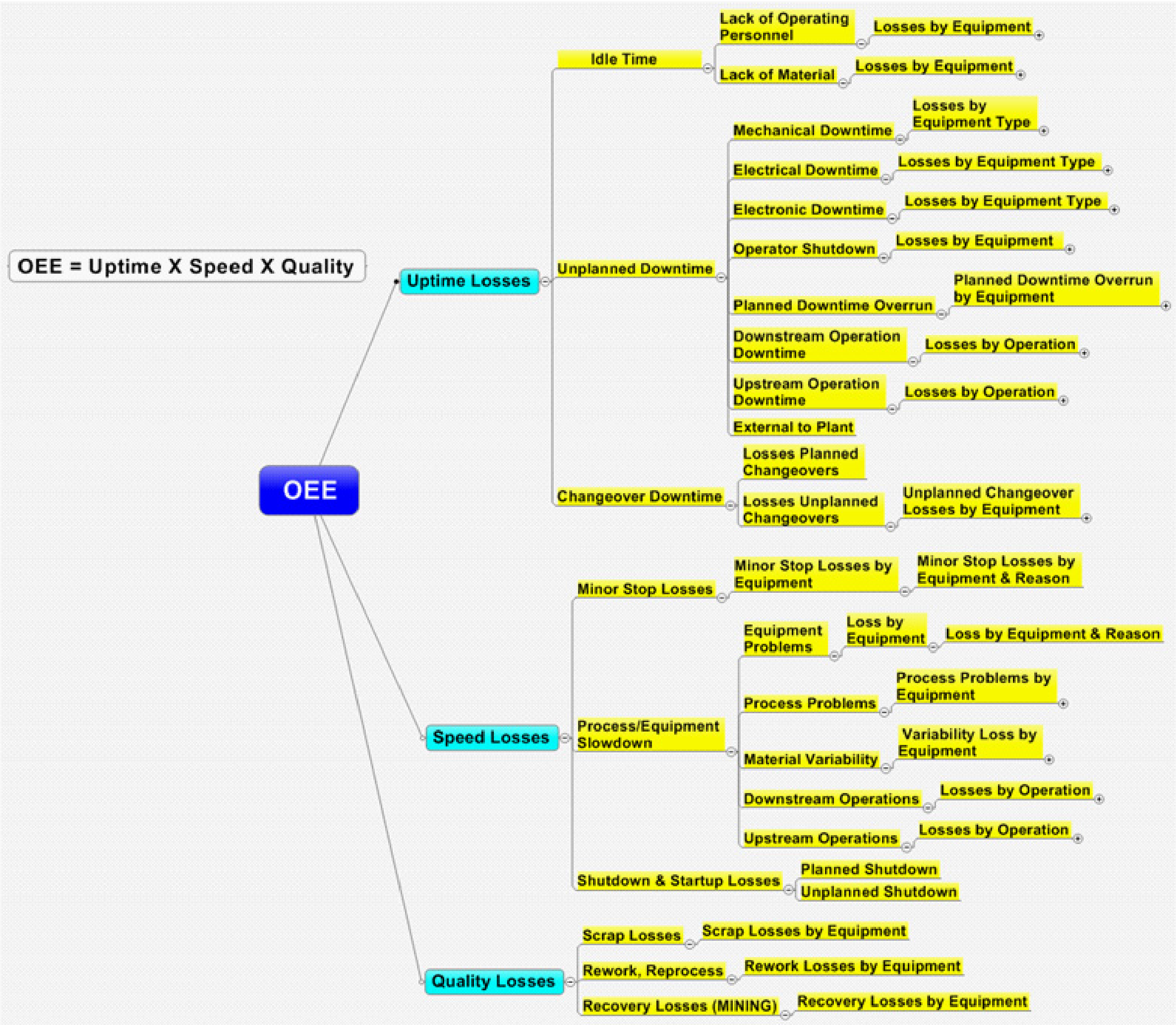
We can then further break down the categories to get to even more detail. For example, Unplanned downtime can be broken down into the following elements:

- Mechanical downtime
- Electrical downtime
- Electronic downtime
- Operator shutdown
- Downstream operation downtime
- Upstream operation downtime
- External to plant downtime
- Planned downtime overruns

In turn each of these elements can be broken down further as to specific equipment and reason for the downtime. The illustration below shows a level 4 loss map. The loss map categories, elements and levels depend upon the level of detail in your data capturing system.

In my experience most companies do a fairly good job of capturing Uptime and Quality losses. On the other hand Speed losses are seldom captured. These can very often be a major loss of productivity. In fact, in many of the plants I have assessed, production losses due to Speed were higher than losses due to unplanned downtime. It seems that when a plant goes down, people notice, but when it slows down, there isn't that sense of urgency that is present when all production has stopped.

For example, we were asked to assess a crushing and conveying operation because management was concerned about lost production due to equipment down time. The assessment, however, showed that 15,000 tons per day were lost due to planned and unplanned downtime and that in excess of 16,000 tons per day were lost due to speed loss. As our investigation pointed out, there were two primary reasons for the speed loss. The first was low load factors on the belts due to several operating factors and the second was that the set point on the feeder belt was manually reduced whenever material was flowing to a particular stock pile. The load factors and set point were automatically captured by the automated control system, but the causes for the reduced production rates were not captured. While all production stoppages were routinely reviewed, slowdowns were not part of the daily review process.



Another example of the hidden productivity improvement opportunities that can be found in Speed losses was a beneficiation plant we were asked to assess to determine the amount of unrealized capacity. The plant bottle neck was considered to be the two primary grinding circuits. Again, equipment availability was thought to be the primary cause of lost production. Our assessment showed that there was indeed unrealized capacity and that the average daily losses due to equipment availability were 3,900 tons per day.

However, the extent of the lost production due to speed loss came as a surprise to management. It was found to be in excess of 4,000 tons per day. As in the previous example, the automated control system captured the speed data and we were able to determine that speeds were reduced for weight, motor load and manual reduction of the set point. However the data regarding the reason for these speed reductions was not captured in any systematic manner. Anecdotal evidence pointed to down-stream problems as the cause of the manual reductions in speed but those reasons were also not captured.

"Gold is where you find it". But successful miners know where to look and have the proper tools to get at the ore. So, in your search for improved productivity, calculate your plants OEE and map the losses. Then, dig into the data to uncover those nuggets hidden in repetitive small delays and production slowdowns. At the same time build a better foundation by improving the business process for equipment maintenance, process control and data capture. You will be rewarded with more golden nuggets of productivity than even Midas could imagine.

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reaching higher